TBC with High Temperature Phase Stability for Low Emission-High Efficiency Gas Turbine Engines, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

Exhaust emissions from civil subsonic aircraft are the most significant source of pollution in the higher troposphere and lower stratosphere. However, reducing NOx emissions is at odds with turbine engine efficiency and performance: increasing thermal efficiency by boosting the pressure ratio in an engine by 30% leads to a 5% decrease in fuel consumption, but a 100% increase in NOx emissions. Accordingly, the aerospace industry is seeking methods to reduce NOx and CO2 emissions while maintaining or improving current turbine engine efficiency and power.

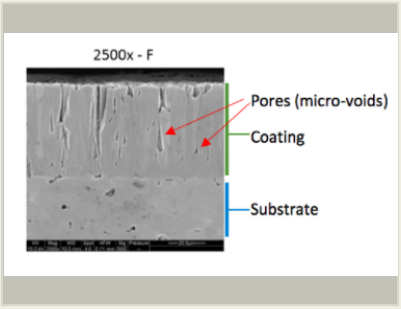
This proposal furthers the development of Thermatin, a novel germanate-based thermal barrier coating (TBC) top-coat material with phase stability to 1800C+. Thermatin's high temperature phase stability enables a potential 200C+ increase in allowable TBC surface temperatures in aircraft and industrial turbine engines over today's standard. This increase would directly support lower energy requirements for active cooling in lean-burn engines, reduced NOx and CO2 emissions, and improved overall engine efficiency.

Germanate-based TBCs have previously been demonstrated to meet target parameters established by the turbine engine industry for use in next-generation high efficiency/low-emission turbine engines, including high temperature phase stability, low intrinsic thermal conductivity, low density and high coefficient of linear thermal expansion. The proposed effort aims to demonstrate high temperature phase stability in thin coating form and optimization for resistance to CMAS attack. Our research efforts will be directed toward meeting performance requirements in the following areas: 1. establishing deposition parameters that produce phase stable Thermatin coatings with standard morphology using electron beam physical vapor deposition (EB-PVD), 2. demonstrating high temperature phase stability in thin-coating form, and 3) demonstrating high temperature structural stability when exposed to CMAS contaminants.

Anticipated Benefits

This proposal directly addresses the NASA directorate goals and the Durability and Protective Coatings Branch goals for decreasing NOx and CO2 emissions in advanced combustion engines while preserving or increasing engine efficiency. Thermatin also aligns with several non-emission focused projects within NASA's sub-divisions, including the Entry System and Technology Division's contributions to the design and material properties for the SpaceX Dragon capsule re-entry system.

Thermal barrier coatings will play a key role in enabling future emissions reductions and efficiency gains as a result of improved combustion techniques. Germanate-based TBCs with high temperature phase stability and low thermal conductivity are an ideal candidate to meet the market need for coatings that support the stringent requirements of tomorrow's gas turbine engines for



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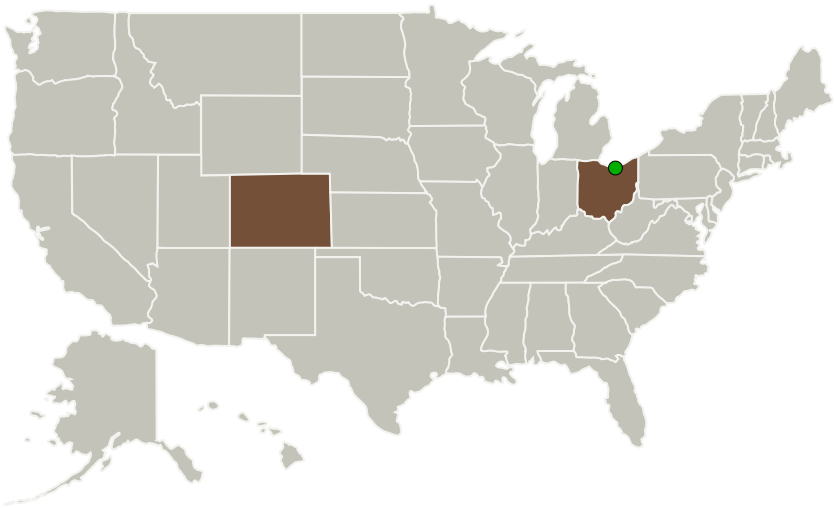
commercial aviation and industrial use.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Thermatin Industries, LLC	Lead Organization	Industry	Boulder, Colorado
Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations	
Colorado	Ohio

Project Transitions

July 2018: Project Start

February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/138532)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Thermatin Industries, LLC

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

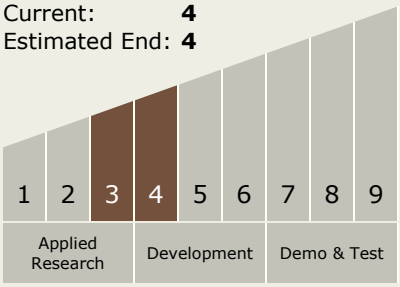
Carlos Torrez

Principal Investigator:

Mike Schmitt

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



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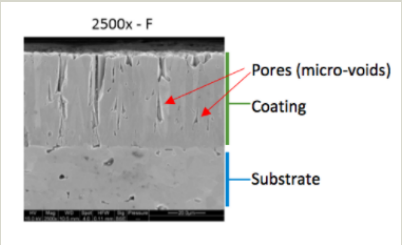
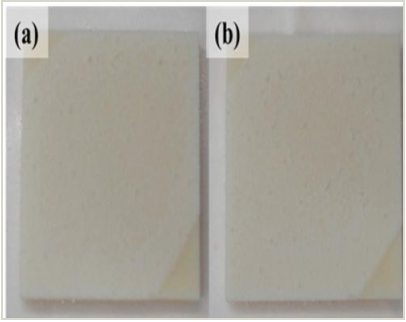
Images



Briefing Chart Image
TBC with High Temperature Phase Stability for Low Emission-High Efficiency Gas Turbine Engines, Phase I
(https://techport.nasa.gov/image/126429)



Final Summary Chart Image
TBC with High Temperature Phase Stability for Low Emission-High Efficiency Gas Turbine Engines, Phase I
(https://techport.nasa.gov/image/128698)

Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.3 Aero Propulsion
    - TX01.3.1 Integrated Systems and Ancillary Technologies

Target Destination

Earth